PART I - ADMINISTRATIVE

Section 1. General administrative information

Title of project

Evaluate An Experimental Re-Introduction Of Sockeye Salmon Into Skaha Lake

BPA project number: 20124
Contract renewal date (mm/yyyy): ☐ **Multiple actions?**

Business name of agency, institution or organization requesting funding
Colville Confederated Tribes

Business acronym (if appropriate)

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NPPC Program Measure Number(s) which this project addresses
2.2G, 2.2H, 3.2C, 3.2F, 4.1A, 4.2A, 7.1A, 7.1C

FWS/NMFS Biological Opinion Number(s) which this project addresses

Other planning document references
Integrated System Plan for Salmon and Steelhead Production in the Columbia River Basin (CBFWA 1991, p. 315 Action 10)

Short description
Evaluation of an experimental re-introduction of sockeye salmon into Skaha Lake in the Okanagan River Basin. Assess risks and benefits, formulate hypotheses, develop an experimental design and analytical tools.

Target species
Sockeye salmon

Section 2. Sorting and evaluation

Subbasin
Okanagan River

Evaluation Process Sort

CBFWA caucus	Special evaluation process	ISRP project type
Mark one or more caucus	If your project fits either of these processes, mark one or both	Mark one or more categories
☒ Anadromous fish ☐ Resident fish ☐ Wildlife	☐ Multi-year (milestone-based evaluation) ☐ Watershed project evaluation	☐ Watershed councils/model watersheds ☐ Information dissemination ☐ Operation & maintenance ☐ New construction ☒ Research & monitoring ☒ Implementation & management ☐ Wildlife habitat acquisitions

Section 3. Relationships to other Bonneville projects

Umbrella / sub-proposal relationships. List umbrella project first.

Project #	Project title/description

Other dependent or critically-related projects

Project #	Project title/description	Nature of relationship

Section 4. Objectives, tasks and schedules

Past accomplishments

Year	Accomplishment	Met biological objectives?

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Disease risk assessment	a	Compare the disease and infection status of fish above and below the dams
		b	Determine if there are environmental conditions specific to the lakes in question that would either put fish at extraordinary risk for developing disease or that would maintain introduced infectious agents
		c	Assess the opportunity for re-introduced

			fish to interact with susceptible resident fish or to extend the distribution of important pathogens
2	Exotic species re-introduction risk assessment	a	Review available fish inventory information in the Okanagan river system below Skaha lake, and in Skaha and the southern portion of Okanagan lake
		b	Inventory exotic fish species and habitat use in each of these two areas
		c	Complete a literature review on habitat requirements for exotic species of concern (i.e. species identified in tasks a and b as being present in the Okanagan sytem below Skaha lake but not in Skaha or Okanagan lakes)
		d	Assess the availability of suitable habitat for species of concern in Skaha and Okanagan lakes
		e	Compile the information from tasks a-d to complete an assessment of the risk of exotic species introduction to Skaha and Okanagan lakes.
3	Inventory existing habitat and opportunities for habitat enhancement	a	Review of literature for evidence of beach-stream spawning plasticity in sockeye salmon populations and to determine attributes of sockeye spawning and incubation habitat
		b	Identification of potential areas of beach-spawning habitat in Skaha Lake
		c	Assessment of potential areas of beach-spawning habitat in Skaha Lake
		d	Field inventory of potential sockeye spawning/incubation habitat in the Okanagan River between Okanagan and Skaha Lakes and Okanagan River and Skaha Lake tributaries
		e	Identification of opportunities for sockeye habitat enhancement and development (e.g. spawning channels, lower tributary spawning gravel placement, etc.) and preliminary engineering feasibility assessments
4	Develop life-cycle model of Okanagan salmonids, including interactions with resident kokanee	a	Literature review to compile information on life-cycle of Okanagan salmonids
		b	Design document that describes general structure and assumptions of a life-cycle model
		c	Multi-agency workshop to review model structure and assumptions
		d	Develop model
		e	Develop user interface
		f	Documentation

5	Develop experimental design	a	Multi-agency workshop to review existing information and formulate hypotheses about potential effects of experimental reintroduction on sockeye salmon and resident species.
		b	Survey/compile baseline data to test hypotheses (including assessment of Wenatchee stock as quasi-control)
		c	Design alternative implementation designs and monitoring programs to collect data
		d	Test alternative designs and monitoring programs in context of entire life-cycle using life-cycle model (developed in Objective 4)
6	Finalize plan for experimental re-introduction of sockeye salmon into Skaha Lake and associated monitoring programs	a	Multi-agency workshop to: review results of Objectives 1-5 and develop experimental management plan; develop workplan for obtaining necessary approvals and additional funding
		b	Obtain necessary funding / approval for implementation of plan
		c	Multi-agency workshop to review progress on obtaining approval/funding; finalize plans for experimental re-introduction

Objective schedules and costs

Obj #	Start date mm/yyyy	End date mm/yyyy	Measureable biological objective(s)	Milestone	FY2000 Cost %
1	11/1999	01/2002			45.00%
2	11/1999	1/2002			23.00%
3	11/1999	7/2002			10.00%
4	11/1999	10/2000			22.00%
5	11/2000	10/2001			0.00%
6	11/2001	10/2002			0.00%
				Total	100.00%

Schedule constraints

Completion date
FY2002

Section 5. Budget

FY99 project budget (BPA obligated):

FY2000 budget by line item

Item	Note	% of total	FY2000
Personnel	Project management / Contract administration	%7	16,000
Fringe benefits		%0	
Supplies, materials, non-expendable property		%0	
Operations & maintenance		%0	
Capital acquisitions or improvements (e.g. land, buildings, major equip.)	Boat, electrofishing equipment, and other fishing equipment	%12	27,000
NEPA costs		%0	
Construction-related support		%0	
PIT tags	# of tags:	%0	
Travel	Workshop expenses	%7	15,000
Indirect costs		%0	
Subcontractor	Obj. 1-Disease risk assessment (Craig Stephens)	%35	77,000
Subcontractor	Obj. 2 - Exotic species risk assessment (contractor to be determined)	%14	30,250
Subcontractor	Obj. 3 - Habitat inventory (contractor to be determined)	%6	13,200
Subcontractor	Obj. 4 - Life-cycle model (ESSA Technologies Ltd.)	%19	41,000
Other		%0	
		TOTAL BPA FY2000 BUDGET REQUEST	$219,450

Cost sharing

Organization	Item or service provided	% total project cost (incl. BPA)	Amount ($)
Canada Department of Fisheries and Oceans	Spawning estimates, information on sockeye-kokanee interactions	%9	26,000
Columbia River Inter-Tribal Fisheries Commission	Age and stock composition sampling of Columbia R. sockeye at Bonneville Dam	%14	40,000
		%0	
		%0	
		Total project cost (including BPA portion)	$285,450

Outyear costs

	FY2001	FY02	FY03	FY04
Total budget	$223,000	$135,000		

Section 6. References

Watershed?	Reference
☐	Columbia Basin Fish and Wildlife Authority, 1991. Integrated System Plan for Salmon and

	Steelhead Production in the Columbia River Basin. June 1, 1991.
☐	Sustainable Fisheries Foundation. 1998. Toward Ecosystem-based Management in the Upper Columbia River Basin: Workshop Summary Report. Preliminary Draft, October 1998.
☐	Fryer, J.K. 1995. Columbia Basin sockeye salmon: Causes of their past decline, factors contributing to their present low abundance, and the future outlook. Ph.D. thesis. University of Washington. 274 pp.
☐	United States Army Corps of Engineers. 1998. Annual fish passage report for 1998. Portland and Walla Walla Districts.
☐	Gustafson, R.G., T.C. Wainwright, G.A. Winans, F.W. Waknitz, L.T. Parker, and R.S. Waples. 1997. Status review of sockeye salmon from Washington and Oregon. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-33, 282 pp.
☐	Nehlson, W., J.E Williams, and J.A. Lichatowich. 1991. Pacific salmon at the crossroads: Stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16(2):4-21.
☐	Washington Department of Fisheries, Washington Department of Wildlife, and Western Washington Treaty Indian Tribes. 1993. 1992 Washington State salmon and steelhead stock inventory. Wash. Dep. Fish Wildl., Olympia, WA, 212 pp. plus 5 regional volumes.
☐	Peters. C.N., D.P. Bernard and D.R. Marmorek. 1998. Should sockeye be re-introduced to Okanagan Lake? An exploration of potential benefits, impacts and uncertainties. ESSA Technologies Ltd., Vancouver, B.C., 50 pp.
☐	Korman, J., T.M. Webb, and E. Parkinson. 1993. User's guide to the B.C. large lakes kokanee model: Version 2.0. Vancouver, B.C., 70 pp.
☐	Green, R. H. 1979. Sampling design and statistical methods for environmental biologists, John Wiley & Sons, Toronto.
☐	Schmitt, R. J., and C. W. Osenberg. 1996. Detecting Ecological Impacts: concepts and applications in coastal habitats. , Academic Press, Toronto, 401.
☐	Skalski, J. R., and D. H. McKenzie. 1982. A design for aquatic monitoring programs. Journal of Environmental Management, 14, 237-251.
☐	Stewart-Oaten, A., W. M. Murdoch, and K. R. Parker. 1986. Environmental impact assessment:"Pseudoreplication" in time? Ecology, 67(4), 929-940.
☐	Sainsbury, K. J. 1991. Application of an experimental approach to management of a tropical multispecies fishery with highly uncertain dynamics. ICES mar. Sci. Symp., 193, 301-320.
☐	Keeley, E. R., and C. J. Walters. 1994. The B.C. watershed restoration program: summary of the experimental design, monitoring, and restoration techniques workshop. 1, B.C. Ministry of Environment, Lands and Parks, and Ministry of Forests, Vancouver B.C.
☐	McAllister, M. K., and R. M. Peterman. 1992. Decision analysis of a large-scale fishing experiment designed to test for a genetic effect of size-selective fishing on British Columbia pink salmon (Oncorhynchus gorbuscha). CJFAS 49: 1305-1314.
☐	Walters, C. 1994. Use of gaming procedures in evaluation of management experiments. Canadian Journal of Fisheries and Aquatic Sciences, 51, 2705-2714.
☐	Walters, C. J., and R. Green. 1997. Valuation of experimental management options for ecological systems. Journal of Wildlife Management, 61(4), 987-1006.
☐	Gilbert, R. O. 1987. Statistical Methods for Environmental Pollution Monitoring, Von Nostrand Reinhold, New York.
☐	Hurlbert, S. H. 1984. Pseudoreplication and the design of ecological field experiments. Ecological Monographs, 54(2), 187-211.
☐	Hairston , N. G. 1989. Ecological experiments: purpose, design, and execution, Cambridge University Press, New York.
☐	Hall, J. D., M. L. Murphy, and R. S. Aho. 1978. An improved design for assessing impacts of watershed practices on small streams. International Vereinigung fur Theoretische und Angewandte Limnologie, 20, 1359-1365.
☐	Walters, C. J., J. S. Collie, and T. Webb. 1988. Experimental designs for estimating transient responses to management disturbances. Canadian Journal of Fisheries and Aquatic Sciences, 45, 530-538.
☐	Mellina, E., and S. G. Hinch. 1997. Overview of large-scale ecological experimental designs

	and recommendations for the British Columbia Watershed Restoration Program. 1, Watershed Restoration Program, Vancouver, B.C.
☐	Anderson, J. L. 1998. Errors of Inference. In V. Sit and B. Taylor, (eds.), Statistical Methods for Adaptive Management Studies, Land Management Handbook 42, Ministry of Forests Research Program, pp. 69-87.

PART II - NARRATIVE

Section 7. Abstract

Historical records indicate that sockeye salmon were once found in most of the lakes in the Okanagan Basin. Currently, the only sockeye population within the Okanagan Basin is found in Osoyoos Lake. Abundance of this stock has declined significantly in the last fifty years. Tribes and First Nations in the U.S. and Canada have proposed re-introducing the species into Okanagan Lake, which has a large rearing capacity. However, assessing the potential benefits and risks associated with a re-introduction of sockeye salmon into Okanagan Lake is difficult because of uncertainties about factors that determine production of Okanagan sockeye, and potential interactions with other species in Okanagan Lake.

A recent workshop to discuss these issues recommended that sockeye be re-introduced to Skaha Lake as an experimental management strategy to resolve some of these uncertainties. The purpose of this proposal is to assess the risks and benefits of an experimental re-introduction of sockeye salmon into Skaha Lake. The assessment will be accomplished through comprehensive assessments of disease and other potential risks, development of quantitative modeling tools, and an evaluation of the potential learning benefits of this action. These elements will be integrated into an overall experimental management plan through a cooperative multi-agency process that involves U.S. and Canadian agencies. The information contained in this plan, as well as the information gathered from the re-introduction itself, will support future decisions on rebuilding strategies for this stock and for other sockeye stocks in the Columbia basin.

Section 8. Project description

a. Technical and/or scientific background

Of all salmon species in the Columbia Basin, sockeye have suffered the greatest reduction in abundance. Historic abundances of Columbia Basin sockeye may have exceeded 4,000,000 fish (Fryer 1995). With the building of mainstem dams, this declined to a mean of 103,000 fish in the 1960's and 71,200 in the 1970's before rebounding to 96,900 in the 1980's (Fryer 1995). The mean number returning thus far in the 1990's has been only 49,300, and only 22,300 since 1994 (Fryer 1995). The 1998 estimate of Columbia Basin sockeye at Bonneville Dam is 13,121 (USACE 1998). The decline in sockeye salmon populations since 1938 is statistically significant (Fryer 1995).

Historical records indicate that sockeye salmon were once found in most of the lakes in the Okanagan Basin, including Osoyoos, Skaha, Vaseaux, Palmer, and Okanagan Lakes (Fryer 1995). Together, these lakes account for over 41% of the lake rearing area accessible to sockeye salmon in the Columbia Basin (Fryer 1995), suggesting that run sizes to the

Okanagan basin must have been substantial. However, the distribution of sockeye within the Basin has been restricted by the construction of impassable dams at Okanagan Lake in 1915, Palmer Lake in 1916, and Vaseaux Lake in 1921 (replaced by McIntyre Dam in 1954). Zosel Dam, at the south end of Osoyoos Lake, was completed in 1927. Currently, the only sockeye population within the Okanagan Basin is found in Osoyoos Lake. These sockeye are one of the last remaining transboundary stock of Pacific salmon that migrates within the Columbia Basin, and are one of only three remaining stocks of sockeye salmon in the Columbia Basin (Wenatchee Lake and Redfish Lake are the others). It is estimated that together the Wenatchee Lake and Okanagan sockeye stocks currently occupy less than 4% of the historic amount of rearing lake habitat in the Upper Columbia River region (Gustafson et al. 1997).

Estimates of adult escapement of Okanagan sockeye based on Wells Dam counts are available since the dam was constructed in 1967. These counts do not reflect mortality incurred upstream of Wells Dam or in the Okanagan River. There is a general downward trend in the number of returning adults, from escapements of more than 100,000 fish in the late 1960's to 3811 in 1998 (Gustafson et al. 1997; J. Fryer pers. comm.). A recent NMFS status review of this stock concluded that although it is not in danger of extinction, its status "bears close monitoring" because of concerns about the stock's overall health (Gustafson et al. 1997). Previous stock status documents have classified this stock as "of special concern" (Nehlson et al. 1991), "healthy" (WDFW et al. 1993), and "of highest concern" (CBFWA 1991).

Sockeye production in Osoyoos Lake is limited by marginal spawning, incubation, and rearing habitat, losses during downstream migration due to irrigation withdrawal and vertical control structures in the Okanagan River, and nine major dams in the Columbia River. Fryer (1995) found a significant and negative correlation between number of mainstem dams passed and the survival of Okanagan sockeye from spawner to adult returns to the mouth of the Columbia, suggesting that passage through these dams is a major limiting factor in this life stage. Commercial, sport and native harvests in the lower Columbia River, and high water temperatures in the Okanagan River during the adult upstream migration period also limit production of Okanagan sockeye.

Okanagan sockeye remains a potentially significant cultural and food resource for the Colville Confederated Tribes in the United States, the Tribes along the lower Columbia River, and the Okanagan First Nations in Canada. Therefore, these tribes have recently established an objective of restoring sockeye productivity in the Okanagan Basin to former levels, and towards that end has proposed developing a strategy for re-introducing the species into Okanagan Lake. Okanagan Lake has a surface area of 34,997 hectares, compared to 2332 ha for Osoyoos Lake and 995 ha for Lake Wenatchee. Although there are a number of differences in productivity and community structure between the three rearing lakes that affect juvenile capacity, the potential increase in rearing capacity associated with Okanagan Lake is therefore substantial.

There are potential risks associated with a re-introduction of sockeye salmon into Okanagan Lake. One of these is the effects of sockeye on the resident Okanagan Lake kokanee population, which has declined significantly in the past several years because of competition with introduced mysid shrimp, and the reduction of biological productivity in the lake as municipalities have moved to more complete effluent treatment. Another concern is the possibility of the transmission of diseases that are currently not found in Okanagan and Skaha lakes from re-introduced sockeye to resident fish. An additional concern is the risk that exotic species (e.g., tench, yellow perch) that have become established in southern Okanagan lakes (principally as a result of purposeful introductions in the US Columbia/Okanagan river system) may be able to extend their range to Skaha and Okanagan Lakes through fish ladders provided at the outlets of Vaseaux (McIntyre Dam) and Skaha Lakes (Okanagan Falls dam) for natural upstream migration of sockeye.

The relative magnitude of the potential benefits and risks of reintroducing sockeye salmon to Okanagan Lake is of obvious importance not only to the Colville Confederated Tribes and the Okanagan First Nation, but also to other stakeholders that share water and biological resources of the Okanagan lakes. However, assessing those risks and benefits is difficult because of uncertainty about factors that determine the production of Okanagan sockeye, and their potential interactions with other species in Okanagan Lake. These uncertainties must be considered and (to the greatest possible extent) resolved, before the success of re-introducing sockeye salmon into Okanagan Lake, and other strategies for increasing the productivity of Okanagan sockeye, can be evaluated. An additional complication is that the factors that affect survival of Okanagan sockeye through its various life stages come under the jurisdiction many different agencies in the U.S. and Canada. This jurisdictional complexity necessitates a widely-based, cooperative approach to assessing alternative strategies to enhance this stock.

As a first step in assessing the potential risks and benefits of reintroducing sockeye salmon into Okanagan Lake, a multi-agency workshop was held in November of 1997. U.S. agencies represented at the workshop were the Columbia River Inter-tribal Fisheries Commission, Colville Confederated Tribes, and the Douglas County Public Utilities District. Canadian agencies included the Okanagan Nation Fisheries Commission, the Canadian Columbia River Intertribal Fisheries Commission, the Canadian Department of Fisheries and Oceans, and the British Columbia Ministry of the Environment. The workshop was facilitated by ESSA Technologies Ltd. Of Vancouver, B.C. Workshop discussions a cooperative, ecosystem-based process for addressing the issues associated with re-introducing sockeye salmon into Okanagan Lake were consolidated into a Draft Action Plan, which was distributed in March of 1998 (Peters et al. 1998).

Some of the key elements of the Draft Action Plan were to:

a) assess strategies to recover Okanagan sockeye in the context of their entire life-cycle, and continue with a shared, cooperative process that involves all parties concerned with Okanagan sockeye on both sides of the Canada-U.S. border.
b) consider the effects of such strategies on the rearing lake ecosystem. These principles have since been developed further at a workshop on applying ecosystem-based management in the Upper Columbia River Basin (Sustainable Fisheries Foundation 1998).
c) build a life-cycle model to better understand the factors limiting sockeye production and their interactions, and use quantitative methods such as decision analysis to evaluate rebuilding strategies and experimental management strategies.
d) conduct an experimental re-introduction of sockeye salmon into Skaha Lake to test hypotheses about the potential benefits to sockeye and potential risks to the Okanagan Lake ecosystem.

Re-introducing sockeye salmon into Skaha Lake (item d) offers potential rebuilding benefits by increasing the amount of rearing habitat available to Okanagan sockeye. Perhaps more importantly, a reintroduction of sockeye into Skaha Lake offers an opportunity to implement an experimental management approach to learning about interactions between sockeye salmon and resident species in the Okanagan system of lakes and the relative importance of various factors that influence overall survival. This information will be extremely valuable in future evaluations of re-introduction of sockeye into Okanagan Lake, and for other sockeye rebuilding strategies throughout the basin. The purpose of this proposal is to implement the Draft Action Plan by evaluating an experimental re-introduction of sockeye salmon into Skaha Lake. Actual implementation of the re-introduction and monitoring programs will be covered in a future proposal to the Fish and Wildlife Program.

b. Rationale and significance to Regional Programs

This proposal addresses the following specific measures in the 1995 Columbia Basin Fish and Wildlife Program.
2.2G (Transboundary species): The Okanagan sockeye stock is the last transboundary sockeye salmon stock in the Columbia Basin, and its overall survival is influenced by human activities on both sides of the border. Human activities in the U.S. that affect overall survival include vertical control in the Okanagan River, 9 dams on the mainstem Columbia River, and directed commercial, sport, and tribal fisheries. This points to a need for United States support and participation in the multiagency process advocated by this proposal (Task 4-c; Task 5-a, Task 6-a). The potential benefits to the United States of larger returns of Okanagan sockeye through increased commercial, sport, and tribal fisheries on this stock in the mainstem Columbia and Okanagan Rivers are substantial. Catches of sockeye salmon in the lower Columbia River (Zones 1-5, 6) are estimated to have exceeded 1 million fish in the late 1800's, but have been minimal in recent years (Fryer 1995). Other benefits to the United States of the proposed research include expansion of the knowledge base for sockeye salmon (Task 3-a; Task 4-a; Task 5-b) and development of tools to assess restoration strategies for this species (Objective 4). The knowledge and tools developed through the proposed research will provide useful inputs to assessments of strategies for other Columbia Basin sockeye stocks.

2.2H (Learning from implementation) – An experimental reintroduction of sockeye salmon into Skaha Lake represents a deliberate attempt to implement a restoration strategy in such a way as to maximize the amount of learning. Although an adaptive management approach is a central principle in the Fish and Wildlife Program, there are few examples in the region where this approach has been taken. The proposed research is the first step in developing an adaptive management action in the region that could serve as a case study for future adaptive management strategies in the region. This application of experimental management has an advantage in that the stock in question is not currently ESA-listed. This avoids some of the legal and practical constraints on implementing adaptive management on endangered stocks.

3.2C (Key Uncertainties) –Objective 3, Task 4-a, and Objective 5 are specifically designed to collect information on the relative contribution of various human activities to overall survival of Okanagan and Wenatchee (Task 5-b) sockeye. The model delveloped under objective 4 will provide a tool for examining the effects of various hypotheses about the relative contributions of human activity to overall survival. The tasks under Objective 5 and 6 will develop a plan for an experimental reintroduction of sockeye salmon into Skaha Lake. When undertaken, this experiment will produce needed information on the relative importance of the quantity and quality of juvenile rearing habitat on overall returns of sockeye salmon in the Okanagan basin.

3.2F (Regional analytical coordination) – The model of overall survival of sockeye salmon developed in Objective 4 will incorporate alternative hypotheses about factors that may influence overall survival of Okanagan sockeye. Task 4-c calls for multi-agency workshops to develop the model and review model outputs. Participation by key agencies in the U.S. and Canada in model development is essential to ensure that a wide range of alternative hypotheses are developed, and that all hypotheses are evaluated in a systematic and rigorous framework. This is similar to the approach taken by PATH (Plan for Analyzing and Testing Hypotheses) in its modeling work for Snake River spring/summer chinook.

4.1A (Salmon rebuilding principles)
Principle 1. The goal of the proposed research is to evaluate strategies for rebuilding a weak upriver stock, Okanagan basin sockeye.
Principle 2. Part of the evaluation is to assess the risks to resident species through competitive interactions (Objective 4, Task 5-a and d), spread of disease (Objective 1), and introduction of exotic species (Objective 2).
Principle 3. The proposed research takes a whole life-cycle view of restoration strategies (Objective 4; Tasks 5-a, 5-b, and 5-d). An overall life-cycle focus is necessary because survival improvements in one life-stage may be cancelled out by survival reductions in another life-stage (e.g. higher smolt to adult survival of Okanagan sockeye may lead to larger returns to the Columbia River, which may trigger higher harvest rates under a stepped harvest rate schedule).
Principle 4. Columbia River sockeye stocks once supported substantial harvest rates, and remains a potentially significant cultural resource for for Indian Tribes and First Nations in the United States and Canada. Rebuilding the Okanagan sockeye stock would benefit these ceremonial and food fisheries, as well as commercial, sport, and tribal fisheries in the lower Columbia River.
Principle 5. The experimental management plan developed through this proposal (Objective 6) will form the basis for experimentally reintroducing sockeye to Skaha Lake and implementing monitoring programs necessary to address critical uncertainties about the role of rearing habitat in overall survival, its importance relative to other factors that influence overall survival, and the potential interactions with resident species.
Principle 6. The proposed research is not dependent on hatchery production.

4.2A (Guiding principles for research) – The evaluation of risks and benefits of an experiment re-introduction of sockeye into Skaha Lake is intended to identify critical uncertainties and assess their effects (Objectives 1, 2, 3, 5), and to develop a plan to reduce those uncertainties through experimental management (Objective 6). Evaluation of uncertainties and plans to reduce uncertainties will be conducted in the context of the entire life-cycle through development of a life-cycle model for Okanagan sockeye (Objective 4). The information gained through these tasks will be disseminated in a regional forum (Task 4-c, 5-a, 6-a).

7.1A (Evaluation of carrying capacity)– The purpose of the proposed research is to assess the risks and benefits of restoring sockeye salmon to Skaha Lake, which was historically used by sockeye for spawning, incubation, and rearing. Specific tasks are to inventory the amount of spawning and incubation habitat in Skaha lake (Tasks 3-b to 3-d), and to identify opportunities for habitat enhancement (Task 3-e). Therefore, this research will help to assess the effectiveness of restoring freshwater habitat in Skaha lake for Okanagan sockeye. Portions of what is learned through this assessment, and ultimately through the experimental reintroduction itself, will be applicable to evaluating strategies for enhancing freshwater habitat of other sockeye stocks in the Columbia basin.

7.1C (Collection of data) –Task 5-b calls for collection of information on various measures of stock survival and productivity to serve as a baseline for comparison with measurements taken after the experimental re-introduction. As part of this task, we propose to scope and collect similar information for Wenatchee sockeye. Because the Wenatchee stocks passes through fewer dams than the Okanagan sockeye, this stock could serve as a downstream control for the Okangan stock. Collection of baseline survival and productivity data for both of these stocks will improve the knowledge base for Columbia River sockeye.

The Integrated System Plan developed by the Columbia Basin Fish and Wildlife Authority (1991) classified the Okanagan sockeye stock as "of highest concern" and made a recommendation to "evaluate current production potential and habitat conditions necessary to support the sockeye population" (CBFWA 1991, p. 315). The proposed research is consistent with that recommendation, in that the purpose is to develop a plan to conduct a management experiment that will both restore rearing habitat and assess the effects of the habitat restoration on production.

c. Relationships to other projects

Various groups in the upper Columbia basin have an interest in strategies to restore Okanagan sockeye salmon. These groups include the Colville Confederated Tribes, the United States Columbia River Inter-Tribal Fisheries Commission (CRITFC), the upper Columbia Public Utilities Districts (Grant, Chelan, Douglas), the Okanagan Nation Fisheries Commission (ONFC), and the Canadian Columbia River Intertribal Fisheries Commission (CCRIFC). These agencies, and others, have implemented various projects associated with the Okanagan basin. Some are funded by BPA through the Fish and Wildlife Program (e.g. BPA project 9502100 – Okanagan Watershed Planning, sponsored by the Colville Confederated Tribes). Others are funded independently. Examples include habitat restoration and assessment programs for tributaries to the Okanagan River by the Colville Confederated Tribes, a preliminary disease risk assessment by the ONFC of re-introducing sockeye salmon into Skaha Lake, an assessment of selective upstream fish passage technologies sponsored by the ONFC, radio-tag studies of Okanagan sockeye by Douglas PUD, and stock composition and ageing analyses at Bonneville Dam by CRITFC. While these studies are not necessarily inter-dependent, all are focussed on the Okanagan basin. However, to date there has been little coordination among them. This proposal provides a process for integrating these studies into a systematic, multi-agency framework for evaluating hypotheses about the effects of various factors on Okanagan sockeye, which would then form the basis for an experimental management plan for re-introducing sockeye to Skaha Lake. While research would continue to be conducted independently by these agencies, this research could be better coordinated to provide clearer information on overall life-cycle processes, and the results would be disseminated and integrated into a broader regional forum. Other regional analytical groups, such as PATH (BPA 9600600), perform similar functions in other sub-basins. Such analytical coordination has helped to enhance the scientific rigor of research conducted under the Fish and Wildlife Program.

d. Project history (for ongoing projects)

n/a

e. Proposal objectives

The overall objective of this proposal is to build on the 1998 Draft Action Plan (Peters et al. 1998) by conducting an evaluation of an experimental re-introduction of sockeye salmon into Skaha Lake. This evaluation will quantify the potential risks and benefits associated with this experiment and its associated monitoring programs, using newly-developed analytical tools, in a cooperative and integrated process that involves all interested agencies in both Canada and the United States. The final products of the proposed research will be 1) comprehensive risk assessments to support decisions on an experimental reintroduction of sockeye into Skaha Lake, and 2) an experimental management plan than outlines how best to implement the re-introduction (and associated monitoring programs) to maximize the amount of learning.

Objective 1: This objective is to assess the risk of disease transmission from re-introduced sockeye to resident species in Skaha Lake by addressing 3 key questions:
1) Is the disease and infection status of fish above and below the dams the same? (Task 1-a)
2) Are there environmental conditions specific to the lakes in question that would either put fish at extraordinary risk for developing disease or that would maintain introduced infectious agents? (Task 1-b)
3) Would there be sufficient opportunity for re-introduced fish to interact with susceptible resident fish or to extend the distribution of important pathogens? (Task 1-c)
The product of this objective would be a report that systematically addressed each of these questions, drew conclusions regarding the degree of risk associated with disease introduction into the Okanagan lake system, and made recommendations for minimizing this risk.

Objective 2: The tasks under this objective will assess the risk of accidental introduction of exotic species to Skaha and Okanagan Lakes associated with the provision of fish ladders at downstream barriers, and investigate feasible methods for reducing or eliminating these risks. The primary product will be a report that documents the assessed risk of exotic species introduction, and makes recommendations for reducing this risk. In a related, independently-funded, project, the Okanagan Nation Fisheries Commission is conducting an assessment of the feasibility of using selective upstream fish passage technologies which would provide passage for salmon but not exotic species. The results of this work will be used in developing recommendations to reduce or eliminate the risk of exotic species introduction. These recommendation will be included in the final exotic species introduction risk assessment report (Task 2-e).

Objective 3. The potential for sockeye salmon production from Skaha Lake and its tributaries is unknown and may be limited by the availability of suitable sockeye spawning and incubation habitat. This objective is to determine whether spawning habitat is likely to be limiting, and whether the amount of habitat can be increased. The primary product of this objective will be a report that documents the amount of such habitat, identifies opportunities for enhancing available habitat, and includes preliminary engineering feasibility assessments.

Objective 4. A life-cycle model of Okanagan sockeye will be needed to

a) project the effects of re-introduction of sockeye into Skaha Lake on overall life-cycle survival. Projected responses will be needed to determine whether these effects will be large enough to detect, given the design of the monitoring program and the magnitude of natural variability in sockeye production.
b) Model interactions between sockeye and resident kokanee in Skaha lake, and their effects on overall life-cycle survival rates of sockeye. Competitive interactions (e.g. for food, or spawning habitat) may affect the life-cycle response of sockeye to re-introduction.

The product of this objective will be a model that projects changes in production of Okanagan sockeye (measured as # of spawners produced, or spawner to spawner survival rate) in response to different re-introduction designs, given alternative hypotheses about the effects of various factors on overall survival. The model will have a graphical user interface that allows gaming with various model assumptions and inputs, and a User's Guide.

Objective 5. This objective will evaluate the various ways that an experimental re-introduction could be implemented (i.e. how many fish to be reintroduced, what time of year, re-introduction schedule, what mitigation measures are necessary given the assessments in Objective 1-3), and the various monitoring programs associated with the re-introduction. Some designs may provide more information than others, depending on how they are implemented and how rigorous the monitoring is. Therefore, the primary measure of performance for comparing alternative designs will be the amount of learning that is possible, recognizing that there are other constraints (e.g. budget, time) must be taken into consideration. The primary product of this objective will be a report that: a) identifies hypotheses about potential effects of experimental re-introduction on sockeye and resident species; b) Summarizes baseline data for testing hypotheses; c) describes alternative implementation and monitoring designs; and d) documents their performance in terms of how much can be learned.

Objective 6. This objective is to finalize a plan for experimental re-introduction of sockeye salmon into Skaha Lake and associated monitoring programs. Based on the work done in Objectives 1-5, an experimental management plan will be developed through multi-agency workshops. Key elements of the plan will include:

a) how the re-introduction will be implemented
b) what mitigation or enhancement measures are necessary
c) what baseline data needs to be collected before and after the reintroduction
d) how baseline data should be collected (i.e. the design of the associated monitoring program)
e) what approval processes must be completed (e.g. approval may have to be obtained from the Canadian federal-provincial transplant committee), and a plan for completing those processes
f) what additional funding will be required to implement the plan, and a plan for obtaining those funds

f. Methods

Methods for Task 1-a.

i) Pathogen and parasite surveys. Fish will need to be captured and killed for diagnostic sampling. While special efforts should be directed towards pathogens of special concern, a general screen for viral, bacterial and parasitic pathogens should be conducted. Sample sizes will vary, but in general will need to be high because of the assumed low prevalence of many of the diseases of interest (>60 fish per group). Several hundred fish taken from different life stages should be collected annually. While salmonids may be emphasized, non-salmonids, particularly reservoir species should be collected as well. Final sample sizes will be affected by the budget and the success of trapping.
ii) Sentinel fish. Small groups of sentinel fish (rainbow trout) should be placed in strategic locations within the lake system above and below the dams. These fish should be closely monitored for signs of disease and periodically sampled for the presence of pathogens or parasites. (Note - the sockeye rearing pens in south Osoyoos lake could act as a sentinel pen)
iii) Outbreak Investigations. All fish die-offs should be promptly investigated and appropriate samples submitted for examination.
iv) Challenge experiments on local stocks. Expose fish captured from Skaha lake or its tributaries to some of the pathogens of concern to look at their response. The experiments would be conducted under controlled laboratory settings to make sure the pathogens do not escape.

Methods for Task 1-b.
Environmental survey - Portions of this task can be conducted in conjunction with other tasks (e.g. Task 2-b)
i) Invertebrate survey focussing on organisms important in the lifecycle or transmission of important fish pathogens or parasites.
ii) Water quality measurements should be taken to assess (1) the capacity of the lakes environment to support introduced pathogens or parasites within the lakes, (2) the general quality of the lakes in terms of fish stressors
iii) An inventory of resident fish to identify species at risk or potential alternate hosts for disease causing agents.
iv) An assessment of the carrying capacity and amount of niche overlap that would occur if sockeye were re-introduced.

Methods for Task 1-c.
Survey of the movement of fish, fish products and their associated pathogens
i) Mapping to assess the suitability of various waterways to allow fish movement. This should be overlapped with information on the distribution of resident fish.
ii) A survey of the extent of movement of fish outside of the lakes including enhancement or re-stocking projects and sport fishing.

Methods for Tasks 2-a, 2-c, and 2-d
Review of existing literature on fish distribution (Task 2-a), habitat requirements for exotic species (Task 2-c), and physical information on Skaha and Okanagan lakes (Task 2-d).

Methods for Tasks 2-b
Electrofishing and other sampling to determine habitat distribution and usage by exotic species .

Method for Task 3-a
Literature review on spawning characteristics of sockeye salmon.

Method for Task 3-b
Review of existing hydrographic, topographic and other information to identify potential spawning areas in Skaha lake

Method for Task 3-c
Scuba surveys of areas identified in task 3-b.

Method for Task 3-d
Field surveys of potential spawning habitat in Okanagan River and Skaha lake tributaries.

Method for Task 4-a
Literature review to compile information on Okanagan sockeye. This would include information on sockeye-kokanee-mysid interactions in lakes of different trophic status, as discussed at the 1997 Okanagan sockeye workshop (Peters et al. 1998).

Method for Task 4-b
The design document will follow from the information collected in task a. It will describe the general structure of the model, and the assumptions on which the model will be based.

Method for Task 4-c
Conduct a workshop with all interested agencies to review the design document and finalize the structure and assumptions of the model. Participants will be invited from agencies that participated in the November 1997 workshop, as well as other interested agencies that did not attend that workshop. The workshop will be facilitated by ESSA Technologies Ltd. ESSA has many years of experience in facilitating workshops of this type, and facilitated the November 1997 Okanagan sockeye workshop. ESSA also has experience with Fish and Wildlife Programs in the region through its facilitation and coordination role in PATH (Plan for Analyzing and Testing Hypotheses, BPA Project 9600600). Independent, neutral facilitation is critical for allowing productive dialogue and building consensus in multi-agency workshops.

Method for Task 4-d
We envision a reasonable simple model that would evolve over time to include more complexity. The model would keep track of the abundance of sockeye salmon in Osoyoos and Skaha lakes, as well as the abundance of kokanee in Skaha lake. The 'kokanee-equivalent' approach used in the Large Lakes Kokanee Model (LLKM; Korman et al. 1993) could be used to implicitly represent the effects of competition on sockeye in the first phase model, without incorporating all of the other details in LLKM.

The response of sockeye populations would be based on survival rates through individual life stages (spawning, freshwater rearing, juvenile migration, ocean residence, adult migration), and the effects of various stressors in each life stage. For example, survival in the downstream migration stage will depend primarily on the survival rate of fish passing through the nine reservoirs and dams on the mainstem Columbia River. The model will be designed so that other, more detailed models of processes in individual life stages could be "plugged in" to the overall life-cycle model.

Method for Task 4-e
The user interface needs to be structured for easy use by people who are not experienced modelers (for training use), but also with the ability to change key assumptions and input data by more technical personnel.

Method for Task 4-f
As with the user interface, the documentation needs to include both simple instructions for using the model, and more detailed information on model structure.

Method for Task 5-a
Conduct a multi-stakeholder workshop to establish the objectives, scope, and alternative hypotheses to test for an experimental re-introduction of sockeye into Skaha Lake. This meeting will be professionally facilitated by ESSA Technologies Ltd.

The objectives of the workshop would be to:
1. Establish clear objectives for monitoring.
2. Define the spatial and temporal scale of interest (e.g. detect impacts at the regional or local scale; annual vs. seasonal estimates). Such considerations will determine when and where you sample. This in turn will influence the size (i.e. number of spatial replicates) and length (i.e., number of temporal replicates) of the monitoring program.
3. Develop explicit testable hypotheses from these objectives that link actions to outcomes.
4. Choose variables to measure that address the hypotheses. If fish productivity is of concern, is it better to measure population (e.g., abundance) or individual (length) type variables? Consider the size of the measurement error or bias associated with potential variables.

These workshop objectives follow the requirements and general principles for monitoring and experimental design that have been described by many authors (e.g., Green 1979; Gilbert 1987; Hurlbert 1984; Hairston 1989; Schmitt and Osenberg 1996).

Method for Task 5-b
Review existing information related to the hypotheses developed in Task 5-a. Measurements taken following an experimental reintroduction can be compared to this data to estimate effects. The baseline information also provides a way to approximate the variability, trends, cycles, and correlations likely to be present in the data collected after the re-introduction (Gilbert 1987). These characteristics should be considered when designing the sampling and monitoring programs associated with the experimental re-introduction (Task 5-c) (Green 1979). Baseline data will be reviewed for both Okanagan and Wenatchee sockeye. Because the Wenatchee stock passes through fewer dams than the Okanagan stock, it may serve as a downstream control for assessing the relative magnitude of dam impacts on Okanagan fish. The utility of the Wenatchee stock as a control stock will depend on similarities and differences in the life history, genetics, and other characteristics of the two populations. Data relating to these similarities and differences will be reviewed during this task.

Method for Task 5-c
Design alternative monitoring designs, using the information from Tasks 5-a and 5-b. Many experimental designs are possible. Examples include: Intensive before-after study (Hall et al. 1978), Extensive before after study (Hall et al. 1978), Intensive post-treatment study (Hall et al. 1978), Extensive post-treatment study (Hall et al. 1978), Control-Treatment Pairing (Skalski and McKenzie 1982), Before-After Control Impact Design (Stewart-Oaten et al.

1986), and the "Staircase design" (Walters et al. 1988). Mellina and Hinch (1995) discuss the rationale behind many of these designs, and their advantages and disadvantages. Appropriate designs will depend on the objectives, scope, and hypotheses defined in task 5-a, and on the data that is reviewed in task 5-b.

Method for Task 5-d

An experimental management action is evaluated by assuming some underlying hypothesis that relates system response to that action, then simulating the effects of that action. The simulated data include both sampling error and natural variability. The data are analyzed to see if the hypothesized response can be detected and how long it will take to detect. This approach is known as "gaming"; a good description is found in Walters (1994).

The life-cycle model developed in Objective 4 will be used in this context to demonstrate the trade-offs between the precision of estimates and the costs of achieving this precision for different experimental / monitoring designs (see Anderson 1998). Costs can be expressed either as economic costs (e.g. Walters and Green 1997), or in terms of increased biological risks. For example, a large number of sockeye re-introduced into Skaha Lake may increase effect sizes and, consequently, the precision of estimated variables. However, large releases may also increase the risk of exotic species re-introduction or of negative effects on resident kokanee populations. Biological effects on sockeye and resident kokanee of alternative designs will be explored with the life-cycle model, but risks due to disease and exotic species introductions will be based on the assessments done under objectives 1 and 2. Trade-offs between alternative designs can be formally evaluated using techniques such as decision analysis (McAllister and Peterman 1992; Walters and Green 1997; Sainsbury 1991; Keeley and Walters 1994).

g. Facilities and equipment

Most of the tasks can be completed with existing standard facilities and equipment. Task 1-b and 2-b require electrofishing and other sampling equipment to inventory habitat usage and distribution. The assessment of disease risks (Task 1-a) may require facilities and equipment to which access is limited. However, preliminary discussions with the Pacific Biological Station indicate that they would be interested in serving as a diagnostic facility and would accommodate the necessary technician and graduate student. The Animal Health Centre (BC Ministry of Agriculture) is also interested in providing diagnostic services for this project on a cost-recovery basis. We therefore have indications that access to reputable diagnostic facilities would not be a limiting factor.

h. Budget

Objective 1. This amount is required to pay for access to the specialized diagnostic equipment and facilities needed for conducting disease assays on fish, and to hire a qualified fish disease specialist to perform the analyses.
Objective 2. Budgeted amount includes $2750 for a subcontractor to review existing fish inventory information (Task 2-a), and $27,500 for conducting four exotic species inventories and assessments of habitat use during the fiscal year (Task 2-b). These inventories will be extensive, covering the following areas: north basin of Osoyoos Lake, Okanagan River from McIntyre Dam to Osoyoos Lake, Vaseaux Lake Okanagan River from Okanagan Falls to Vaseaux Lake, Skaha Lake, and Okanagan River between Okanagan and Skaha Lakes.

Objective 3. Budgeted amount is $2750 for subcontracted work to review the literature on sockeye spawning habitat usage (Task 3-a), $2750 for a subcontractor to identify potential areas of beach-spawning habita (Task 3-b), and $7700 for scuba surveys of potential beach-spawning habitat (Task 3-c).
Objective 4. Budgeted amount of $41,000 is for subcontracted work to build a life-cycle model. This will require considerable time and effort to scope out existing information, conduct a multi-agency workshop to ensure that the model incorporates all relevant information and hypotheses, and to build a flexible tool for evaluating management actions under alternative hypotheses.
Personnel ($16,000). For project management and contract administration. Amount is based on approximately 10% of subcontracted costs for Objectives 1-4.
Equipment ($27,000) To purchase a boat, electrofishing equipment, and other equipment necessary to inventory fish distributions in Skaha Lake as part of Task 2-b. The same equipment will be used for inventory work done in Task 1-b. Because the inventory work in Tasks 2-b and 1-b will be undertaken seasonally over a number of years, it is more economical to purchase this equipment than it would be to rent it.
Travel ($15,000) Attendance and travel expenses for key personnel to attend multi-agency workshop (Tasks 4-c) and planning meetings. Costs are based on 15 trips (5 people to attend three workshops and meetings) at an estimated $1000 per trip. This is an estimate only; we will only bill for costs actually incurred.

Section 9. Key personnel

Christopher J. Fisher
P. O. Box 862
Omak, WA 98841
Ph: (509) 422-7427

Education: University of Georgia
School of Forest Resources
B. S. Forest Resources 1990
minor Fisheries management

South Dakota State University
Dept. of Wildlife and Fisheries Sciences
M. S. Wildlife & Fisheries Science 1996
(Fisheries option)

Experience:

Job title: Anadromous Fisheries Biologist II
Employer: Colville Confederated Tribes, Nespelem, WA 99155

Duties: My duties include the management of anadromous fish stocks for population viability and subsistence for tribal members. I conduct and evaluate creel surveys, analyze catch data and develop regulations. I also participate planning and implementation for watershed restoration projects. I prepare correspondences and reports (monthly, quarterly, annually, and conditionally) needed to maintain good communications within the Tribal organization and Federal, State, and Tribal fishery agencies. I develop budget contract proposals, modifications, and reports as required by Tribal policy or established under contract agreements.

Job title: Fisher biologist
Employer: U.S. Forest Service, Okanogan National Forest (Jan 96 to Mar 97)
U.S. Forest Service, Boisen National Forest (Apr 94 to Nov 95)

Job title: Fishery technician
Employer: Idaho Department of Fish and Game, McCall (Jun 90 to Nov 91)

Job title: Research technician
Employer: School of Forest Resources, University of Georgia (Apr 88 to Sep 89)

Expertise:

By acquiring my education in the southwest and midwest and being employed by both state and federal agencies in three different regions of the country my experience in fisheries is extensive and diverse. My wide range of experience has provided me with expertise in collecting, analyzing and interpreting a variety of data and the ability to communicate the results of management activities and research to professional and civic groups via technical reports or presentations.

Vita of

Jeffrey K. Fryer

Education

1995 University of Washington. Ph.D. (Fisheries).

1985 University of New Brunswick at Fredericton, New Brunswick, Canada. MSc(Computer Science).

1979 University of New Brunswick at Fredericton. BSc(Computer Science) with the equivalent of an Honors in Statistics.

Publications

Fryer, J.K. 1998. Frequency of pinniped-scars and wounds on adult spring-summer chinook and sockeye salmon returning to Bonneville Dam. North American Journal of Fisheries Management. 18:46-51.

Fryer, J.K. 1995. Columbia Basin sockeye salmon-causes of their past decline, factors contributing to their present low abundance, and the future outlook. Ph.D. Thesis. University of Washington, Seattle.

Fryer, J.K. and P.R. Mundy. 1993. Determining the relative importance of survival rates at different life history stages on the time required to double adult salmon populations, p. 219-223. *In* R. J. Gibson and R.E. Cutting [ed.] Production of juvenile Atlantic salmon, *Salmo salar*, in natural waters. Canadian Special Publication in Fisheries and Aquatic Sciences 118.

Hatch, D.R., J.K. Fryer, M. Schwartzberg, and D.R. Pederson. 1998. A computerized editing system for video monitoring of fish passage. North American Journal of Fisheries Management. 18:694-699.

Schwartzberg, M. and J.K. Fryer. 1993. Identification of hatchery and naturally spawning Columbia Basin spring chinook salmon using scale pattern analyses. North American Journal of Fish Management. 13: 263-261.

Employment

October 1989 to present: Fisheries scientist at Columbia River Inter-Tribal Fish Commission. Duties have included participating in Phase II of the Snake River Temperature Project, being responsible for data management and participating in statistical analyses and the writing of the final report. I have also supervised CRITFC’s stock identification projects, which has required designing and implementing stock identification experiments, field sampling, creating computer programs, spreadsheets, and databases to manage and analyze data, and publishing technical reports and journal articles.

September 1985 to September 1989: Graduate research and teaching assistant at the University of Washington. Duties included teaching an introductory computer course and assisting the teaching of statistics courses and calculus.

William George Green

Date of Birth: September 8th, 1952
Citizenship: Canadian

Education:

- B.Sc. (Honours) Biology. Carleton University, Ottawa, Ontario, 1976.
  Received Senate Medal for academic achievement in science on graduation.

- Completed course requirements for M.Sc. at the Institute for Animal Resource Ecology, University of British Columbia, Vancouver, BC, 1980-1981.

Related Experience:

1994 – present: **Executive Director,** *Canadian Columbia River Inter-tribal Fisheries Commission*, Cranbrook, BC
Provide policy advice and coordination to First Nations on fisheries restoration and fish habitat protection. Provide technical analysis and advice on fish habitat management, protection and restoration. Plan and coordinate band fish enhancement projects.

1988 – 1994: **Fisheries Program Manager and Clayoquot Sound Regional Biologist,** *Nuu-chah-nulth Tribal Council*, Port Alberni, BC
Trained technicians in salmon habitat inventory, salmon stock assessment, clam stock assessment. Managed fisheries inventory projects. Managed six-person tribal council fisheries program and $1.5 million annual fisheries budget. Provided policy advice and coordination for tribal council and member bands. Member of Southern Panel – Pacific Salmon Commission.

1981 – 1987: **Fisheries and Environmental Consultant,** *West Coast Information and Research Group*, Port Alberni, BC
Training of technicians in salmon habitat inventory, salmon spawner enumeration, juvenile salmon population assessment, clam stock assessment. Coordination and supervision of fisheries inventory and research projects. Fisheries co-management research and policy analysis. Economic analysis of fisheries business opportunities.

1976 – 1980: **Principal Environmental Management Planner,** *Government of Papua New Guinea*, Port Moresby, P.N.G.
Prepared guidelines for, and coordinated environmental assessments for mining, fish processing, forest harvesting and cement production projects.

Dawn Machin
2217 Bridgeview Road
Kelowna, B.C. V1Z 1B8
Tel. (250) 769-2361

SUMMARY OF QUALIFICATIONS

- Experience in water quality, fish sampling and stream assessments
- Experience working with Aboriginal organizations
- Excellent written and oral communication abilities

PROFESSIONAL EXPERIENCE

June 98- Present **Biologist / Fisheries Manager**
Okanagan Nation Fisheries Commission – Westbank, B.C.

Program management, office management, proposal writing, project supervision and report writing. Provide technical assistance to member Bands of the Okanagan Nation. Also act as a liaison with the federal and provincial governments.

Jan. 96 – June 98 **Okanagan Regional Biologist**
Canadian Columbia River InterTribal Fisheries Commission – Kelowna B.C.

Provided technical assistance to the member bands of the Okanagan Nation with respect to fisheries issues. This included arranging meetings and workshops, attending various workshops, participating in technical working groups, drafting a restoration strategy for Okanagan sockeye, developing proposals, managing projects, and report writing.

Aug. 95 – Sept. 95 **Receptionist**
First Nations Health Careers – Vancouver B.C.

Temporary, part-time receptionist – performed general office duties.

May 95 – July 95 **Director, Summer Science Program**
First Nations Health Careers – Vancouver B.C.

Program promotion and planning, and working directly with First Nations high school students in a program encouraging these students to continue their education in science-related studies.

EDUCATION / COURSES

Batchelor of Science, University of British Columbia, Vancouver B.C. 1994
Fish Habitat Assessment and Prescriptions, BC Forestry Continuing Studies, 1996
Electrofishing Certification, Malaspina University-College, 1997

David R. Marmorek

Birthdate: **December 6, 1952**
Citizenship: **Canadian**

Post-Secondary Education

- **M.Sc. Zoology,** University of British Columbia, 1983. Thesis topic: Effects of lake acidification on zooplankton community structure and phytoplankton-zooplankton interactions: an experimental approach. 397 pp.
- **B.E.S. (Honors), Man-Environment Studies and Mathematics,** First class honors, University of Waterloo, 1975.

Professional Experience

1993 - now	**Director,** ESSA Technologies Ltd.
1991 - now	**Adjunct Professor,** School of Resource and Environment Management, Simon Fraser University.
1983 - 1993	**Director,** ESSA Environmental and Social Systems Analysts Ltd.
1981 - 1983	**Systems Ecologist,** ESSA Environmental and Social Systems Analysts Ltd.
1975 - 1978	**Applied Ecologist/Urban Planner,** Proctor and Redfern Ltd.

Relevant Experience and Publications

- used maximum likelihood estimation models and decision analysis to assess the impacts of power plant water withdrawals on Hudson River fish species (for the New York Dept. of Environmental Conservation)
- coordinated an interagency group of fisheries modellers, policy advisors and peer reviewers in a series of analyses of Columbia River salmon stocks
- guided research, monitoring and modelling activities to restore salmonid populations in Kennedy Lake, BC, working with native bands, fisheries agencies, logging companies, and local community groups
- served as modeller, facilitator and data analyst for a series of projects which resulted in the development of a regional model of aquatic effects of acidic deposition with a focus on fisheries and six other classes of aquatic biota.
- major contributor to the 1990 NAPAP Integrated Assessment. Responsibilities included critical analysis and synthesis of studies of impacts of acid deposition on aquatic systems, simulation modelling, and coordination of a team of 15 scientists and modellers;

Korman, J., D.R. Marmorek, G. Lacroix, P.G. Amiro, J.A. Ritter, W.D. Watt, R.E. Cutting, D.C.E. Robinson. 1994. Development and evaluation of a biological model to assess regional scale effects of acidification on Atlantic salmon. Can. J. Fish. Aquat. Sci. 51:662-680.

Marmorek, D.R. and J. Korman. 1993. The use of zooplankton in a biomonitoring program to detect lake acidification and recovery. Water, Air, and Soil Pollution 69: 223-241.

Marmorek, D.R., M.L. Jones, C.K. Minns, and F.C. Elder. 1990. Assessing the potential extent of damage to inland lakes in eastern Canada due to acidic deposition. I. Development and evaluation of a simple "site" model. Can. J. Fish. Aquat. Sci. 47: 55-66.

Thornton, K., D. Marmorek, P. Ryan, K. Heltcher, and D. Robinson. 1990. Methods for projecting future changes in surface water acid-base chemistry. State-of Science/Technology Report 14. Prepared for National Acid Precipitation Assessment Program. 271 pp.

Marmorek, D.R., D.P. Bernard, C.H.R. Wedeles, G.D. Sutherland, J.A. Malanchuk, and W.E. Fallon. 1989. A protocol for determining lake acidification pathways. Wat. Air and Soil Poll. 44: 235-257.

Marmorek, D.R. 1984. Changes in the Temporal Behavior and Size Structure of Plankton Systems in Acid Lakes. In: Early Biotic Responses to Advancing Lake Acidification. G.R. Hendrey (ed.), Butterworth Publishers, pp. 23-41.

Calvin N. Peters

Birthdate: **April 26, 1967**
Citizenship: **Canadian**

Post Secondary Education

- X **Masters of Resource Management**, Simon Fraser University, Burnaby, B.C. 1996
  Interdisciplinary training in integrated environmental management, specialization in policy analysis and quantitative approaches to decision-making in fisheries management
- X **B.Sc. Ecology**, Simon Fraser University, Burnaby, B.C. 1992.
  (Specialization in evolutionary and behavioural ecology)
- X **Diploma of Technology (Honors), B.C. Institute of Technology (1988)**
  Professional training in financial management, capital budgeting and financing, and computer systems analysis, design, and programming.

Professional Experience

1996 - now (Sept-)	**Systems Ecologist**, ESSA Technologies Ltd., Vancouver, BC. Responsibilities include: proposal preparation, workshop facilitation, data analysis, ecological modelling, statistical and decision analysis, and report writing.
Jan. 01/96- Aug. 31/96	**Research Assistant**, Simon Fraser University, Burnaby, BC. (Contract position with Dr. Randall Peterman)
1994-1995	**Recreational Fisheries Policy Analyst**, Fisheries Branch, B.C. Ministry of Environment, Lands, and Parks

Mr. Peters will carry out much of the detailed model development work, in consultation with other participants. Calvin Peters is highly skilled at integrating the biological, economic, and social components of environmental problems into comprehensive solutions. Mr. Peters has an interdisciplinary background in computer systems, financial management, ecology, and natural resource management. He specializes in quantitative and analytical tools for the development and evaluation of environmental policy and practices. Mr. Peters has applied his skills with the B.C. Ministry of Environment, where he developed a decision-making framework for lake stocking policy in the management of B.C. freshwater fisheries, and with the B.C. Ministry of Forests, where he assisted in the development and delivery of a workshop on quantitative approaches to decision-making for Ministry staff. He has considerable expertise in analytical and technical writing, and has prepared technical documents for a Royal Society of Canada expert panel on Global Change and Canadian Marine Fisheries while doing post-graduate research at Simon Fraser University. Since joining ESSA in the fall of 1996, Mr. Peters has been leading the application of decision analysis to endangered Columbia River salmon stocks through PATH. He has also helped develop designs and working modules for fish simulation tools. He has received numerous academic awards.

Publications and Reports

Peterman, R.M., C. Peters. S Frederick and C. Robb. (in press) Benefits of taking uncertainties into account when making decisions in fisheries management: Example applications of Bayesian decision analysis. In: T. Pitcher (ed.). Reinventing Fisheries Management: Proceedings of a Symposium held February, 1996.

Peterman, R.M. and C. Peters. 1998. Decision Analysis: Taking Uncertainties into Account in Forest Resource Management. In: V. Sit and B. Taylor (eds.). Statistical Methods for Adaptive management Studies. Resource Branch, B.C. Ministry of Forests, Victoria B.C., Land Management Handbook No. 42.

Peters, C.N., D.R. Marmorek, and T.M. Webb. 1997. Design of FFIP Management Model: Summary of FFIP Meetings held December 5,6, 1996 and February 5, 1997 at University of British Columbia. Prepared by ESSA Technologies Ltd., Vancouver, BC for Integrated Resource Management Section, Research Branch, BC Ministry of Forests, Victoria, BC, 28 pp. and appendices.

Section 10. Information/technology transfer

Information transfer will be accomplished largely through multi-agency workshops. These workshops will integrate research conducted by various agencies into a structured regional process. This will facilitate transfer of information and research findings between scientists and agencies, and will strengthen regional science by providing a common framework for scientists to share and critique ideas and results.

We also anticipate that various aspects of this work would be published in peer-reviewed journals. For example, the habitat surveys and the development of the life-cycle model will generate information and tools that may be applicable outside of the Okanagan basin. Another product will be a comprehensive risk assessment to be submitted to the Canadian federal-provincial transplant committee. Finally, we propose to place the products generated through this process on web sites to allow regional access to the information. Appropriate web sites are still to be determined, but the BPA Fish and Wildlife web site and the Streamnet web sites are two possibilities.

Congratulations!